Mars Surveyor in Mangala Valles: 2. Probe Design; P. Eric Peterson[1] and Mary G. Chapman[2]; [1]Proteus Applied Technologies, 150 N. Hill Drive, Suite #3, Brisbane, CA 94005; [2]US Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ 86001.

As a scientifically promising potential Surveyor Landing Site, Mangala Valles was recently approved for geologic analysis and initial mission planning (identifying operational scenarios and exploration strategies) [1]. One of the basic goals of the landed mission will be to provide a description of the materials forming the surface of the Mangala Valles site. Specifically, we desire a data return concerning: the compaction of soils; the average grain size, shape, and density; the permeability; the porosity; and the abundance of carbonates and silicates. Instruments designed to measure these properties would provide data to allow: the characterization of the physical state of Mars, its past geologic history, and better planning and design for future planetary exploration beyond the year 2000. The length of Mangala Valles channel system (about 850 km long) and the presence of numerous sites of high scientific interest along it argue for a networked mission configuration with considerable mobility built-in. A nominal configuration consists of a lander with a rover for studies near the landing site, balloon, and multiple balloon-borne surface probes.

As part of our study, a innovative concept and high-level engineering review will be provided for a surface probe containing simple, miniaturized, low-power, and low-cost instruments to measure basic soil properties. The probe concept incorporates instruments having baseline soil analysis capabilities and a VIS/NIR spectroscopic sensor to estimate the abundance of carbonates and silicates. A telemetry antenna can relay data back to a lander or orbiter. The primary goals of probe design include: low cost measurement of multiple soil properties; autonomous operation that poses virtually little risk to other mission goals; a total device mass of 2 kg or less; a flexible system architecture that supports multiple sensor configurations; complementary integration of robust, simple, proven sensors in a fault tolerant configuration; deployment by aerial means; and cost-effective multiple deployments. The following is an initial Proteus/USGS team ideas for a small, autonomous, low-energy, multi-function soil interrogation device (MSID) capable of acquiring a broad range of soil properties.

The MSID is housed in a hinged clam shell package. This design insures proper orientation of the MSID instruments after deployment from the balloon. Several such probes could be deployed by the balloon.

The MSID is intended to have self-checking sensors (optics may be protected from martian dust). As envisioned, the integrated sensor assembly will determine properties including: gas permeability; load-bearing strength, consolidation and cementation; fine content/distribution; aeolian transportability; seismic/acoustic properties: velocity, energy transfer, anisotropy; water/volatile content and distribution; thermal conductivity; and silicate/carbonate ratio. Determination of these parameters is outlined in the following sections.

Gas permeability of the soil in proximity of the penetrator will be measured using a transient pressure decay technique, executed simultaneously with the fines content measurement. These pressure/time data, together with penetration depth and penetrator geometry, will be used to calculate gas permeability. A number of techniques and models have been developed and validated for the transient pressure decay method of permeability measurement [2,3].

The principal technique for inferring near-surface compaction/consolidation is insertion depth of one or more small penetrators: these may include cup, spike, or micro-scoop penetrators [4]; spring or gas driven: low to mid-energy kinetics; integrated sensor(s) to acquire depth-of-penetration data; and multiple sensors for other surface properties integrated with the penetrator.

Content and distribution of near-surface fines will be measured using confined atmospheric turbidity and settling time measurements and implemented using the cup-penetrator configuration and a small gas source to erode the surface and propel fines into suspension [5,6].

Turbidity as a function of time will be measured optically within the chamber after the brief gas discharge. Optical absorption/scattering along multiple paths will be monitored using simple, robust optical sources (LED's and/or laser diodes) and detectors (photodiodes and/or photoresistors).

An additional aspect of fine-content is grain shape/orientation; this also relates to aeolian transportability. Inhomogeneous, preferential grain orientation can be inferred using simple optical scattering techniques.

Aeolian transportability may be evaluated with a particle impact data technique. Impact of particles on exposed surfaces of the sensor package can be measured easily using areas or films of piezoelectric elements (PZT ceramics or PVDF polymer; [7]).

Acoustic properties will be measured using a multi-transducer array integrated with the interior walls of the cup-penetrator. The transducers will be located near the open end of the penetrator to ensure that they can be embedded in, and coupled to, the surface.

Water/volatile content of surface materials within the cup-penetrator will be detected using a simple heat and condense technique. Measuring the distribution of water/volatiles as a function of depth can be achieved with a fiber-optic (FO) coupled reflection spectrophotometer.

Thermal conductivity of surface materials can be measured, simultaneously with the water/volatile content measurement, by acquiring the transient temperature profile, once the heaters are energized. Measurements required for calculation of soil thermal conductivity include: power input to the heaters, probe calibration data, temperature change, and time [8].

Silicate/carbonate ratio can be inferred using VIS-NIR spectroscopic techniques. A candidate approach is to use fiber-optic coupled source detector arrays. Measurements may be performed over wide spectral ranges or at specific fixed wavelengths.

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